Survey of Apple Juice Packed In 1940[1]

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WE hear much about the average man, the average income, and the average yield of crops. Perhaps this hypothetical average does not exist but it typifies a large group. We thought it would be instructive to find out what the average packed apple juice looks and tastes like and how it is made. Therefore, the National Apple Institute, in cooperation with the Eastern Regional Research Laboratory, undertook to make a survey of the apple juice packed in the United States in 1940.

Some of the specific objectives of the survey were as follows:

1. To obtain information as to the methods in use and the quality of juice produced.
2. To determine what makes a good or a poor apple juice.
3. To learn how much is packed and how much could be packed with present equipment.
4. To obtain data which might help in establishing standards.

Samples and Information

FROM the container manufacturers we obtained the names of the packers of apple juice. Dr. Marshall of the Michigan Agricultural Experiment Station also supplied some names. In all, the names of 83 packers were obtained. Some of them did not pack in 1940; some had no juice left at the time we requested the sample; and 15 failed to reply. Sixty samples were received from 52 sources, including samples from some of the experiment stations and from our own experimental work. Two samples produced by the Schwarz machine and one containing sodium benzoate were excluded, because their character was so different from the rest that they could not be directly compared. The samples were representative of the juice packed throughout the country. Samples were submitted from 15 plants in New England and New York, 11 in the Atlantic States, 13 in the Middle West, and 11 in the far West. It should be kept in mind in the following discussion that there may have been a tendency for the packer to ship us his better-grade juice since the selection of the sample was left entirely up to the packer.

Each packer was sent a questionnaire and each was assigned a confidential code number so that he could recognize his sample in the published results of the survey. This questionnaire called for information on: (a) the varieties of apples used; (b) the kind of storage; (c) the type of clarification, if any; (d) the temperature and time of pasteurization; (e) whether deaeration was employed; (f) the 1940 production in gallons; and (g) the capacity of the plant in terms of an 8-hour day and a 26-day month. The replies were very complete and detailed.

Analyses and Scoring

THE age of the samples averaged about 6 months when received. When they were all in, they were subjected to analysis and tests for specific gravity (Brix), acidity, tannin content, color, and volatile flavoring constituents. The usual methods were followed for the first three determinations.

An attempt was made to evaluate the color of the juices against the Maerz and Paul color standards, using plate 12 with all but three cases; for these three, plate 10 was used with one and plate 11 with two. These evaluations were not at all satisfactory, however, and we place but slight significance on the results.

Volatile flavoring esters were determined by distilling a sample of the juice and measuring the amyl esters by a colorimetric method.[4]

A scoring committee was selected consisting of: Mr. C. A. Greenleaf, National Canners Association; Dr. Carl S. Pederson, New York State (Geneva) Agricultural Experiment Station; Mr. C. F. Schmidt, Crown Can Company; and Mr. Roy Stover, Owens-Illinois Glass Company. In addition to these, four from the Regional Laboratory judged all of the samples. Thus, there were from 5 to 8 opinions on the flavor quality of each sample. All of the judges were familiar with packed apple juice. In our opinion the flavor of an apple juice is its most important characteristic. From the standpoint of establishing a market for the juice such characteristics as color, clarity, and nutritive value are secondary. We hold this opinion so strongly that in this survey we have tried to interpret all factors considered in terms of the flavor of the juice. A score card with various headings was set up. The first of these was "typical apple flavor" and the samples were rated from 5 to 1 in decreasing order according to apple flavor. We realized that it would be important to detect, if possible, the cause of low flavor value. Therefore, five other headings under "off-flavor" were set up for the judges to use. These were "green-fruit," "decayed-fruit," "metallic," "cooked," and "other."

[1] A paper of similar context but more brief in scope was presented at the meeting of the National Apple Institute in Columbus, Ohio, June 16-18, 1941.

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[4] We are indebted to Wm. Galler of the Eastern Regional Research Laboratory for developing the method and analysing the juices for amyl esters.

typical apple flavor. They did not agree at all well in picking out the reasons for off-flavors or poor flavors. A sour taste in some cases was ascribed to green apples and in others, was described as a metallic flavor. In a few cases undoubted metallic flavor occurred in samples packed in glass, indicating that the juice picked up the metal from the equipment.

In order to compare the Agricultural Marketing Service findings with those of the above committee, Mr. H. S. Slamp and Mr. R. N. von Glahn of that Service kindly gave their help.

The tentative standards of the Agricultural Marketing Service allow 35 points for color, 35 for absence of defects, and 30 for flavor. A sample rating 90 or better is called "Fancy" or Grade A; 70 to 90, "Standard" or Grade C; below 70, "Off-grade" or "Sub-standard."

TABLE I. DATA OBTAINED ON APPLE JUICE SAMPLES SUBMITTED IN SURVEY OF 1940 PACK

Packer's Code Number	Container	Vacuum Inches	Headspace 16th"	Pasturization Temp. °F.	Time	Varieties Used**	Degrees Brix	Acidity, percent Malic	pH Value	Amyl Esters, Parts per Million	Tannin, Parts per Million	Color, Maerz and Paul, Plate 12	AMS SCORING: Defects	Color	Flavor	Grade	Typical Apple Flavor
1	En. 302x505	20	6	205	—	3, 10, 13, 19, 21, 23, 31	12.5	.43	3.6	13	50	L 9	34	33	20	C	3
3	En. 211x412	14	6	190	1'	16	11.7	.44	3.4	5	100	L 6	32	27	20	C	4
3A	En. 211x412	16	8	190	1'	16	11.4	.44	3.4	11	30	J 9	35	35	30	A	3
4	En. 303x509	11	6	170	3'	1, 4, 5, 9, 17, 19	11.3	.34	3.2	9	100	K 7	30	28	23	C	3
5	Pl. 208x401	6	4	180	3'	3, 7, 13, 23, 31	12.6	.51	3.4	10	130	H 7	34	33	23	C	4
5A	Pl. #10	9	7	180	3'	3, 7, 13, 23, 31	13.5	.50	3.3	12	130	L 8	33	26	21	C	4
6	En. 203x414	15	10	190	10'	16	14.7	.61	3.3	3	160	L 9	26	25	23	C	3
7	En. 405x700	1	7	170	5"	1, 5, 13, 17	12.4	.54	3.2	16	200	L 8	—	—	—	—	3
8	En. #2	17	5	180	40"	13, 15, 19, 23, 29	14.0	.46	3.5	6	90	K 6	33	25	29	A	5
13	Gl. 1 qt.	18	(20)*	170	1'	1, 17	13.4	.64	3.1	10	270	K 5	33	26	21	C	4
15	En. #3 special	17	8	190	7"	5, 28	14.2	.54	3.3	5	140	J 7	—	—	—	—	4
16	Pl. 306x512	14	6	185	8'	——	11.9	.38	3.4	16	80	K 6	32	26	26	C	3
18	Gl. 12 oz.	22	(16)	—	—	1, 14	14.5	.72	3.2	9	100	L 12	34	31	20	C	2
23	Gl. 1 qt. stubby	14	(21)	180	14"	1, 5, 13, 19, 23	14.3	.56	3.3	7	70	J 8	33	34	26	A	4
26	Pl 306x511	10	5	170	1'	2, 13, 28, 30	12.9	.59	3.4	15	270	G 6	28	29	23	C	3
29A	Pl. 303x509	17	7	—	—	1, 5, 9, 11, 14, 17, 25	14.3	.65	3.2	18	90	K 6	32	32	27	A	2
29B	Pl. 303x509	14	6	—	—	1, 5, 9, 11, 14, 17, 25	14.5	.56	3.3	18	80	K 7	34	33	27	A	3
31	En. 303x509	7	6	170	15"	1, 9, 19, 27	13.7	.64	3.3	8	10	L 8	20	25	20	SS	2
32	En. 303x509	14	6	180	—	——	14.3	.66	3.2	13	60	H 7	—	—	—	—	3
33	En. 303x509	16	8	175	—	——	13.2	.69	3.2	9	130	L 7	33	31	24	C	2
33A	En. #3 special	10	6	175	—	——	13.8	.77	3.2	9	220	L 8	33	28	25	C	3
38	En. 303x509	14	5	—	—	1, 5, 9, 17, 19	13.6	.54	3.4	13	30	K 6	32	31	26	C	4
38A	Pl. 303x509	15	6	—	—	1, 5, 9, 17, 19	13.8	.57	3.3	15	50	K 6	33	26	27	C	3
44	Gl. 12 oz. stubby	13	(12)	165	—	1, 5, 16, 22	16.1	.51	3.5	15	100	L 8	35	35	28	A	4
44A	Gl. 12 oz. stubby	13	(12)	165	—	16, 18	15.3	.41	3.5	21	100	L 8	35	35	28	A	4
46	Gl. 12 oz. stubby	0	(17)	165	55'	5, 16, 18, 32, 33	14.8	.36	3.4	25	200	J 8	34	32	30	A	3
46A	Gl. 11 oz. tall	0	(22)	155	30'	5, 16, 18, 32, 33	14.7	.38	3.5	7	170	H 12	34	31	26	A	3
48	En. 303x509	11	4	171	53"	1, 17, 23	13.8	.53	3.4	4	220	L 11	33	32	29	A	4
51	Pl 303x509	9	7	170	4'	1, 10, 17, 26	13.6	.54	3.2	15	50	J 6	32	28	24	C	3
52	En. 306x512	19	5	180	90"	13, 23, 31	13.5	.52	3.4	16	50	L 6	33	32	28	A	4
53	En. 208x400	2	4	175	30"	——	12.7	.45	3.5	17	10	L 5	—	—	—	—	2
55	En. #3 special	16	6	190	30"	1, 13	13.0	.51	3.4	21	40	K 7	34	32	28	A	4
57	Pl. 303x509	14	7	180	—	5, 10, 13	14.5	.44	3.5	16	110	L 8†	33	34	26	A	3
58	En. 303x509	10	4	180	3'	1, 17, 19	14.3	.69	3.2	6	270	L 9	27	27	22	C	3
59	En. 202x312	16	5	190	15"	5, 13, 28	13.1	.45	3.3	—	100	J 7	—	—	—	—	3
60	Gl. 1 gal.	9	(104)	158	75'	5, 33	14.0	.36	3.6	—	370	L 9	33	34	24	C	2
61	Gl. ½ gal.	0	(48)	180	2"	5, 23, 28, 31	12.5	.43	3.5	—	70	J 8	33	33	26	A	3
63	En. 303x509	13	6	190	—	5, 6, 9, 12, 14, 27	11.9	.67	3.2	16	4	J 6	32	33	26	A	3
65	Gl. 1 gal. jug	—	—	180	3'	13, 28	13.7	.47	3.3	8	—	K 8	34	33	27	A	2
68	En. 303x509	20	8	—	—	3, 15, 19, 23	12.7	.40	3.3	15	10	J 6	—	—	—	—	2
69	En. 303x509	17	6	180	—	1, 9	13.1	.70	3.2	12	80	K 6	27	26	22	C	3
70	Pl. 211x414	15	7	188	—	5, 28, 30	13.4	.42	3.5	12	170	K 7	33	34	25	C	3
71	En. 303x509	12	6	180	2"	1, 5, 10, 13, 17	13.8	.59	3.3	15	60	K 6	34	33	28	A	3
72	En. 303x509	15	6	180	—	1, 9, 17, 19	11.2	.55	3.2	8	200	J 7	26	26	23	C	3
73	En. 307x512	17	6	187	13"	——	13.3	.54	3.2	17	100	J 8	34	32	27	A	3
74	En. 303x509	10	4	190	15"	2, 10, 23, 28	13.9	.49	3.4	13	90	I 6	20	20	30	C	4
77	Gl. 1 gal. jug	24	(82)	170	20"	1, 8, 10, 13	13.9	.59	3.4	14	190	L 9	34	26	25	C	3
78	Gl. 32 oz. stubby	17	(38)	Filter	—	16, 18	15.1	.48	3.3	12	70	L 6#	35	35	25	C	2
79	En. 203x312	14	4	—	—	5, 9, 13, 14, 17, 24, 27	12.0	.52	3.4	20	50	K 6	34	34	25	C	3
82	En. 303x509	16	9	180	6"	9, 13, 17, 24	13.8	.50	3.4	16	90	L 9	33	34	28	A	4
84	Gl. 1 qt. stubby	21	(33)	—	—	1, 9	13.5	.68	3.3	17	15	L 6#	34	34	29	A	4
85	Gl. ½ gal. jug	13	(51)	150	30'	5, 26, 28	14.7	.38	3.5	17	160	K 6	34	35	28	A	3
88	En. 303x509	14	7	—	—	1, 9, 20	14.3	.51	3.4	12	40	L 8	33	33	26	A	3
91	Gl. 1 pt. stubby	10	(22)	155	—	1, 14, 17, 18	14.1	.61	3.1	12	50	K 7	—	—	—	—	3

* Figures in parentheses are in cubic centimeters.
** See Code to apple varieties, Table II.
† Plate 10.
\# Plate 11.

General Facts from the Survey

In table I are given the data obtained on the samples. The code numbers assigned to the apple varieties are given in table II. Tables III and IV are summaries of the data arranged in various ways.

TABLE II

Code to Apple Varieties

1. Baldwin
2. Ben Davis
3. Black Twig
4. Cortland
5. Delicious
6. Fameuse
7. Gano
8. Gravenstein
9. Greening
10. Grimes Golden
11. Hubbardston
12. Hyslop
13. Jonathan
14. McIntosh
15. Nero
16. Newtown
17. Northern Spy
18. Pippin
19. Rome Beauty
20. Russet
21. Smokehouse
22. Spitzenburg
23. Stayman Winesap
24. Steels Red
25. Twenty Ounce
26. Wagner
27. Wealthy
28. Winesap
29. Winter Banana
30. Yellow Delicious
31. York Imperial
32. Bellflower
33. White Pearmain

TABLE III

Summary of Apple Juice Survey

	Out of 54 samples
Typical apple flavor rating	
Grade 5 (highest)	1
" 4	15
" 3	29
" 2	9
Container	
Glass	15
Plain tin	11
Enameled tin	28
Storage	
Cold	6
Common	35
Fresh	7
Clarified	43
Enzyme treatment	21
Gelatin-tannin method	4
Heat	2
Centrifuge	2
Direct filtration	14
Deaerated	10
Not deaerated	44

In respect to "typical apple flavor," only one sample graded 5; 15 graded 4; 29 graded 3; and 9 graded 2. None of the samples graded 1. Many individuals found samples that they graded 1 but only the average opinions are given in the table.

About half of the packers used enameled tin containers, about one-fourth used plain tin, and about one-fourth used glass containers.

The majority of the packers used apples from common storage, a few used fresh apples, and others used cold storage fruit. We believe that this information refers only to the samples submitted, because any company for a brief period might use apples of different storage conditions.

Forty-three samples of clarified juice were submitted; of these 43 samples, 21 were clarified by the enzyme process.

Pasteurization temperatures varied from 150° to 205°F., the majority of cases being from 180° to 190°F. The time of exposure to a given temperature affects the pasteurization results. Only one company employed sterile filtration.

Relation of Various Factors to Scoring on Typical Apple Flavor

	Flavor Score 5	4	3	2	Total No. Samples
Container					
Enameled tin	1	8	16	3	28
Plain tin	0	2	7	2	11
Glass	0	5	6	4	15
Storage					
Common	1	11	17	6	35
Cold	0	1	5	0	6
Fresh	0	2	4	1	7
Clarification					
Enzyme	0	6	11	4	21
Gelatin-tannin	0	2	1	1	4
Heat	0	0	2	0	2
Centrifuge	1	0	1	0	2
Direct filtration	0	3	10	1	14
None	0	4	3	2	9
Acidity, as malic					
0.3 — .4%	1	3	11	4	19
.5 — .6%	0	12	16	4	32
.7 — .8%	0	0	2	1	3
Deaeration					
Employed	0	3	4	3	10
Not employed	1	12	25	6	44
Degrees Brix					
11–13	0	11	19	4	34
14–16	1	4	10	5	20
Volatile esters					
0–12	1	6	11	5	23
13–21	0	7	14	3	24

The acidity, calculated as malic acid, varied from 0.3 to 0.8%. In three-fourths of the samples, it fell between 0.4 and 0.6%.

The Brix hydrometer readings varied from 11.2 to 16.1, averaging 13.5. Although we naturally expect that juice of high Brix is going to have better flavor than one of low Brix, this is not borne out in this survey, as will be discussed later.

Only 10 samples were deaerated, while 44 were not.

Over half of the samples had a tannin content below 0.01%. One was 0.04% and it was a very poor juice.

Thirty-three varieties of apples were represented in this study. The varieties used in descending order of frequency are Baldwin, Red Delicious, Jonathan, Northern Spy, Greening, Stayman and Rome. These merely indicate the most frequently used varieties and not necessarily the relative proportions used in the blends.

The total pack represented in this survey was 4,400,000 gallons. If we consider the companies who did not reply and if we consider the juice which is not packed but sold at roadside stands, we can safely say that from 5 to 6 million gallons of apple juice were made in 1940.

Fourteen companies on our list produced over 100,000 gallons each and two of these produced 500,000 gallons each. These 14 companies produced 85% of the total juice represented in this survey.

Of the total gallons packed in 1940, 25% were in plain tin, 38% in glass, and 37% in enameled tin.

The capacities of the plants per month of 26 days of 8 hours each varied from 1,500 to 260,000 gallons with an average of 70,000 gallons. The average calculated length of run was 6 weeks. The actual runs were probably less than this because of operating more than 8 hours per day and for more than 26 days per month. The figures undoubtedly indicate that production could be doubled by working a longer day and a longer season. However, we are not suggesting that the production should be doubled.

The Typical Apple Juice of 1940

THE typical apple juice packed in 1940 was made from a blend of Baldwin, Red Delicious, Jonathan, Northern Spy, and Winesap apples taken from common storage. The Brix is 13.5; the acidity, 0.5%; the tannin, 0.01%. It is a clarified juice produced by enzyme treatment. It was not deaerated. It was pasteurized at 185°, and was packed in 20-ounce enameled cans. After 6 months of storage, it is weak in typical apple flavor, in our judgment. The plant that made this juice had a capacity of 70,000 gallons per month and it made a total of 100,000 gallons.

Possible Causes of Good and Poor Flavor

LET us consider first only those 15 samples which rated 4 or 5 in typical apple flavor. The majority of these were in glass or enameled tin containers and only 2 were in plain tin cans. This might indicate some advantage in using glass or enameled tin. About one-half of them were clarified by some process such as enzyme, gelatin-tannin, or heat treatment and about one-half were not, indicating that clarification makes no difference, so far as these samples are concerned. Although the temperature of pasteurization varied from 165° to 190°F., in 80% of the cases temperatures ranging from 180° to 190°F. were used, indicating that this range may be the most favorable one for pasteurization. Because time is a factor, apparently any temperature is satisfactory so long as it is just sufficient to sterilize in the time allowed. Most of these samples had an acidity of 0.5%, indicating that probably very high or very low acidities are not desirable. All ranges of Brix were found among these samples. Deaeration apparently was not a factor, and neither was the tannin content.

Now let us consider the nine samples which rated 2 in flavor. In most cases, the judges found some decided off-flavor but they were not consistent in deciding the cause. Type of container showed nothing—4 were glass; 3 were enameled tin; and 2 were plain tin. Six were clarified and 2 were not; 3 were deaerated and 6 were not. We would hesitate to conclude, however, that clarification or failure to deaerate were the causes of the low-flavor values.

No one of the factors studied explains good or poor juice. We should bear in mind that these were judged entirely on their typical apple flavor, ignoring appearance, clarity, freedom from defects, and color. Typical apple flavor, therefore, cannot always be attained by choosing one type of container or adopting a particular temperature of pasteurization or meeting a certain acidity or Brix. What is the explanation for this great difference in quality? We believe the most important factors are the quality of the apples and the quickness of handling them during the processing. If poor apples are used, it can hardly be expected that a particular container or pasteurizing temperature, or the employment of clarification or deaeration, will yield a good juice having typical apple flavor. Ten or 15 years ago there was the same difference in quality in tomato juice. This difference does not prevail now. The reasons are that the tomato juice packers have become meticulous regarding the ripeness and soundness of their fruit and the quickness of their processing, and are employing all the tricks of processing that have been discovered by technologic research. The same holds true for grapefruit, orange juice, and pineapple juice. A common term in the apple industry is "cider grade" and this grade is far down the line in quality. It implies that any quality of apple is good enough to put into cider or apple juice. The lesson from the success with these other fruit juices is that good apples must go into the press if good juice is to come out of the can or bottle. Furthermore, the apple juice industry can never become a big business and have general public acceptance so long as mediocre or poor juice is put on the market.

We would expect that the larger companies who can employ chemists to control their processes would be able to put out a better quality of juice than the smaller companies without this technical help. This is not indicated in the present survey. Among the 14 companies who made over 100,000 gallons, the juice of three of them rated only 2 in flavor.

Recommended Process

WE realize that most of the above discussion is negative. Here are a few positive suggestions for making well flavored apple juice, based partly on the facts learned from this survey and partly on experimental evidence obtained in various places. In the first place, we must start with good apples. They may be small but they should be sound and ripe. A blend is always better than a single variety. It is futile to recommend a particular blend because any packer has to use the varieties available in his neighborhood. After the juice is pressed, it may or may not be clarified. Both kinds apparently can be of good quality. A good deal depends on consumers' preferences within a particular region. If the juice is to be clarified, the enzyme process probably leaves better color and flavor in the juice than does the gelatin-tannin process, but it costs more. Centrifuging for the production of a cloudy juice is very satisfactory. It enables the juice to be handled very promptly. Deaeration should probably be employed if plain tin containers are used; otherwise, there does not seem to be much gained by deaerating. Glass containers are satisfactory beyond question since glass is inert and cannot affect the juice. However, breakage and weight have to be considered. Enameled tin is less likely to affect the juice than plain tin. The juice should be flash-pasteurized at 180° to 190°F. for a few seconds and placed in the cans at this temperature-range. The cans should be inverted for 2 or 3 minutes and then cooled quickly.